ASOS Trainer's

Tool Box

For a Better Understanding of Automated Surface Observing Systems

National Weather Service, Surface Observation Modernization Office **December 1995**

Freezing Rain Comes to ASOS

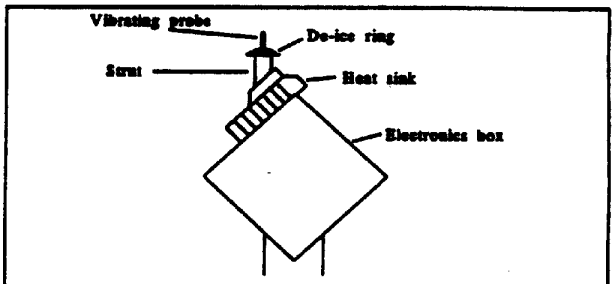
This paper is a condensed version of a presentation made at the Mt. Washington Observatory's "FOCUS 2000: Wind, Ice, and Snow" Conference, June 1995. For the full paper, contact the ASOS Program Office. Direct questions or comments to Hughes STX Corporation (ATTN: Al Ramsey), 43872 Weather Service Road, Sterling, VA 20166; (703/260-0341); aramsey@ccmail.stx.com.

Where Did It Come From And How Does It Work?

Since the late 1980s, the NWS has been evaluating a new sensor to report freezing rain. The technology has a long and successful history as an aircraft ice detector. After going several modifications in the early 1990s, the sensor performed so well in the winter of 1994-1995 that NWS decided to deploy it on the ASOS.

This article will give you a picture of how it works, how well it works, and where it may have problems in detecting and reporting icing conditions.

The new sensor, Rosemount Aerospace Corporation's Model 872C2, detects ice accumulation by monitoring the resonant frequency (nominally 40,000 hertz) of a vibrating magnetostrictive metal tube. The tube is made of a special metal alloy in which the atoms actually elongate when subjected to a magnetic field ("magnetostriction"); the tube is subjected to an oscillating electromagnetic field, and special circuits determine the natural resonant frequency of the tube, which depends on the amount of mass made to vibrate. The resonant frequency decreases with increasing accretion of ice, frost or wet snow. The sensor's de-icing system is activated by the ASOS algorithm when ice, frost or wet snow drive the frequency below a certain value. The sensor is de-iced through internal heating elements, which heat the probe and strut above the boiling point of water for a short time. Frequency values are reported to the ASOS once each minute. The system combines information from the sensor with data from other ASOS sensors to generate the required reports of freezing rain. The ASOS does not report data that indicate the presence of icing *without detectable precipitation*.



Rosemount 872C2 ZR Sensor

A "sensor" event begins (or continues after a de-ice) when the vibration frequency shows ice 0.005 inches of ice accretion and the rate of frequency decrease exceeds about 0.002 inches in 15 minutes. The event ends whenever the frequency indicates an equivalent of less than 0.005" of ice or whenever the rate of ice accretion is less than about 0.002" in 15 minutes.

rain. This algorithm protects the ASOS from falsely reporting rime icing as freezing rain but results in the loss of 0.6% of true freezing rain minutes when precipitation is too light to be detected by the LEDWI (less than about 0.01" per hour).

If the LEDWI is reporting snow (S), any output from the freezing rain sensor will be *overridden*, and the ASOS will report snow.

Unreported Freezing Rain Minutes

CAUSE	# MINUTES (% OF ALL ZR MINUTES)
Unknown (ASOS 1-minute data were not available)	330 (2.9%)
Slow Recovery from De-ice	204 (1.8%)
Clamping (Incr in Freq Caused by Ice Accumulating at Base of Probe)	178 (1.6%)
Snow Override	258 (2.3%)
LEDWI Unable to Detect Precip	67 (0.6%)
Slow or No Accretion	2853 (25.2%)

A "system" freezing rain event is reported from the ASOS only after combining the sensor output with data from the ASOS precipitation identifier:

The Light Emitting Diode Weather Identifier (LEDWI) is an optical sensor that reports precipitation falling through its sensing volume. It is able to discriminate between rain and snow. The LEDWI *must* provide a positive indication of precipitation ("P" or "R") before ASOS can transmit a report of freezing

This algorithm protects the ASOS from falsely reporting wet snow as freezing rain, but results in the loss of 2.3% of true freezing rain minutes when the freezing rain is mixed with snow.

Will It Catch Every Minute of Freezing Rain?

A measure of ASOS's ability to detect freezing rain is provided by the *number of minutes* in which both ASOS and an observer reported freezing rain. During the 1994-1995 test, observers reported 11318 minutes of freezing rain; ASOS reported 12234 minutes.

Although the total numbers of minutes are close (and have been over the last three testing seasons), researchers noted that the ASOS and human do not necessarily report freezing rain at the same time. The number of *coincident* minutes was 7428, or about 66 percent of all human minutes. Detailed analyses of the 3890 minutes of un-reported freezing precipitation are summarized here:

A significant, but indeterminate, fraction of the minutes lost to slow or no accretion are attributed to three causes:

- Micrometeorological differences related to the separation between observers and the ASOS installations: It is entirely possible to have reportable freezing rain at one location but not at another a few thousand feet away. The sites can differ by tens of feet in elevation, especially at temperatures near freezing
- Limitations imposed by "Basic Weather Watch" observing procedures, which do not require continuous monitoring of the weather. Under these procedures, observers may be understandably conservative in their reporting of hazardous situations, and may continue reports of freezing precipitation until they are relatively certain that an event has ended and is unlikely to resume; or
- A difference in the response of objects to slow changes in temperature. The thermal

mass of the 872C2 sensor is known to cause delays in the onset and cessation of icing relative to thin (and highly-responsive) aluminum strips as the temperature slowly falls below or rises above the freezing point. (Consider the delays possible on the cold-soaked wing of a 747.)

Will It Lie to Me?

Researchers found that, of the 12,234 minutes of freezing rain reported by the ASOS, 9771 minutes (80%) were confirmed by an observer as having either freezing rain or freezing drizzle in progress. An additional 467 minutes (4%) were reported during ice pellets accreting on surfaces, but which did not technically constitute a "freezing rain" condition. Sixty-seven minutes (0.5%) can be called true false alarms, directly attributed to wet snow accreting on the probe, briefly mis-identified as "R" or "P" by the ASOS weather identifier, and therefore erroneously reported as freezing rain.

The remaining 1929 unverified ASOS freezing rain minutes are believed to have occurred in three conditions:

- At temperatures near freezing where localized conditions could have existed at an ASOS but not at an observer's location
- Immediately preceding observer reports of freezing rain when the observer's Basic Weather Watch procedures did not pick up the start of an event
- At the end of an event when the 872C2's thermal mass caused the sensor to continue to accrete ice after the ambient temperature warmed above freezing.

Icing Detected from All Sources, 1994-1995

CATEGORY	MINUTES
Freezing Rain	12234
"False" Freezing Rain: Rime or Hoarfrost with High Accretion Rate *(Not Transmitted by ASOS)*	13557
Wet Snow *(Not Transmitted by ASOS)*	1276
Rime or Hoarfrost with Low Accretion Rate *(Not Transmitted by ASOS)*	> 40000
TOTAL	> 68000

How About Ice That Isn't From Freezing Rain?

Including the 12,234 icing minutes actually reported by the ASOS as freezing rain, the 872C2 sensor responded to more than 68,000 minutes of icing from all sources, summarized in the table above.

What's Happening?

Testing in 1994-1995 indicated that the combination of the 872C2 ice detector and the Light-Emitting Diode Weather Identifier provides an effective capability for the ASOS to identify periods of freezing rain, with minimal false alarms.

Sensors will be installed as quickly as they can be manufactured, beginning in November-December 1995 and continuing until more than 300 are installed at NWS, FAA and Navy sites in the United States.

Although this ASOS data might be able to differentiate among glaze, rime, frost and wet snow, neither the NWS nor the Federal Aviation Administration sees a need to provide this information and have planned no formal development activities.

For More Information

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